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I, JULIE BILLINGSLEY, TEAM LEADER EXAMINATION SUPPORT AND
SALES hereby certify that annexed is a true copy of the Provisional specification
in connection with Application No. 2002950421 for a patent by COMBINED
RESOURCE ENGINEERING PTY LTD as filed on 29 July 2002.



WITNESS my hand this
Fifth day of August 2003

J. Billingsley

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ORIGINAL
AUSTRALIA

Patents Act 1990

PROVISIONAL SPECIFICATION

Invention Title: "Fluid Operated Pump"

The invention is described in the following statement:

"Fluid Operated Pump"

Field of the Invention

This invention relates to a fluid operated pump and to a pumping system incorporating such a pump.

5 Background Art

The invention has been devised particularly, although not necessarily solely, for dewatering underground mining operations.

In dewatering of underground mining operations, the water is invariably contaminated with solids. Typically, piston pumps or diaphragm pumps are used
10 for the pumping process. While piston pumps are effective in operation, they involve high capital costs and also high maintenance costs. The high maintenance costs arise because the high wear rates due to the aggressive action of the contaminated water on piston seals. A further contributing factor to the high maintenance costs is the arduous operating conditions to which the
15 pump valving systems, which regulate pump intake and discharge strokes are exposed, involving pump operating rates of some 60 to 80 cycles per minute. Diaphragm pumps are not exposed to the same wear rates as the piston pumps but nevertheless the valving systems are exposed to arduous conditions as diaphragm pumps also operate at some 60 to 80 cycles per minute.

20 There is a need for a pump which can operate at lower pumping rates and therefore be less arduous on valving associated with the pump. This requirement can possibly be met by a collapsible chamber pump, which is a variation of a peristaltic pump. Such a pump utilises a flexible tube having a supply end and a discharge end, with a pumping chamber defined within the
25 tube between the supply and discharge ends. Fluid pressure is employed to compress the tube, with the tube being caused to progressively collapse from the supply end to the discharge end, thereby urging a charge of the fluid within the.

pumping chamber towards the discharge end. Various proposals for such pumps are disclosed in US 3,406,633 (Schomburg), US 4,515,536 (van Os) and US 6,345,962 (Sutter). Each of these proposals utilise a tube which is elastic so that it is compressible to expel the charge of fluid therein and expandable to draw
5 a further charge of pumped fluid into the pumping chamber. The pump tube must therefore have sufficient strength and memory characteristics so that it can elastically return to its expanded shape in order to perform an intake stroke. The duration of the intake stroke is thus regulated by the restoration rate of the elastic pump tube and cannot be otherwise controlled.

- 10 A further deficiency which such pumps is that the pumped fluid is delivered as pulses rather than as a substantially uniform flow.

It is against this background, and the deficiencies and problems associated therewith that the present invention has developed.

- The reference to the abovementioned prior art is for the purposes of background
15 only and is not, and should not be taken as, an acknowledgement or any form of suggestion that the prior art forms part of the general knowledge in Australia.

Summary of the invention

- According to a first aspect of the invention there is provided a pump for conveying a pumped fluid using a actuating fluid, the pump comprising a rigid
20 outer casing defining an interior space, a tube structure accommodated in the interior space, the tube structure being flexible and substantially inelastic, the interior of the tube structure defining a pumping chamber for receiving pumped fluid, the tube structure being movable between laterally expanded and collapsed conditions for varying the volume of the pumping chamber thereby to provide
25 discharge and intake strokes, the region of the interior space surrounding the tube structure defining an actuating chamber for receiving actuating fluid, the pumping chamber being adapted to receive pumped fluid to cause the tube structure to move towards the expanded condition and the pumping chamber thereby undergo an intake stroke, the pumping chamber undergoing a

compression stroke upon collapsing of the tube structure in response to the action of actuating fluid in the actuating chamber.

Preferably, one end of the tube structure is closed and the other end is connected to a port through which pumped fluid can enter into and discharge
5 from the pumping chamber as the pumping chamber performs intake and discharge strokes.

Preferably, the tube structure collapses progressively from the closed end to the other end.

Preferably, the tube structure is maintained in a taut condition between the ends
10 thereof.

Preferably, the tube structure is supported at the closed end thereof.

Preferably, the closed end of the tube structure is movably supported to accommodate longitudinal extension and contraction of the tube structure.

The closed end of the tube structure may be movably supported in any
15 appropriate fashion such as by way of a spring mechanism.

According to a further aspect of the invention there is provided a pumping system comprising a pump in accordance with the first aspect of the invention, a delivery means for delivering pumped fluid to the pumping chamber in timed sequence for causing the pumping chamber to undergo an intake stroke, and means for
20 supplying actuating fluid to the actuating chamber in timed sequence to cause the tube structure to laterally collapse whereby the pumping chamber undergoes a discharge stroke.

The delivery means may comprise a delivery pump.

Typically, the delivery means is only required to operate at a relatively low
25 pressure in the sense that is only required to convey the pumped fluid into the

interior of the tube structure to cause lateral expansion thereof thereby to perform an intake stroke of the pumping chamber.

The actuating fluid may be of any appropriate form, such as hydraulic oil or water. In the case where the actuating fluid is hydraulic oil, the supply means
5 preferably includes a supply circuit incorporating a reservoir for hydraulic oil and a hydraulic pump. The hydraulic circuit also includes an intake and exhaust valve system for regulating the delivery of hydraulic oil into, and the discharge of hydraulic oil from, the actuating chamber in timed sequence. In the case where
10 the actuating fluid is water, the supply means may comprise a water reservoir at an elevated location in order to supply the water at the appropriate pressure head.

The pumping system may comprise two pumps in accordance with the first aspect of the invention operating sequentially such that the pumping chamber of one pump performs a intake stroke while the pumping chamber of the other
15 pump performs a discharge stroke, and vice versa.

Preferably, the two pumps have a common delivery means and a common supply means, with appropriate valve systems controlling the sequence of operation.

Preferably, the or each pump is oriented so that the closed end of the tube
20 structure is elevated in relation to the other end thereof.

Brief Description of the Drawings

The invention will be better understood by reference to the following description of several specific embodiments thereof as shown in the accompanying drawings in which:

25 Figure 1 is schematic elevational view of a pumping system according to a first embodiment;

Figure 2 is a fragmentary view of part of the pumping system of Figure 1;

Figure 3 is a side view of the closed end of a tube structure forming part of the pumping system, shown in a loaded (laterally expanded) condition;

Figure 4 is an end view of Figure 3;

5 Figure 5 is a side view of the closed end of the tube structure, shown in a relaxed (laterally collapsed) condition;

Figure 6 is an end view of Figure 5;

10 Figure 7 is a plan view of a closed end section of a tube structure for a pumping system according to a second embodiment, shown in a loaded (laterally expanded) condition;

Figure 8 is a side view of Figure 7;

Figure 9 is an end view of Figure 8;

Figure 10 is a view similar to Figure 8 with the exception that the tube structure is illustrated in a relaxed (laterally collapsed) condition;

15 Figure 11 is an end view of Figure 10; and.

Figure 12 is a schematic elevational view of a pumping system according to a third embodiment.

Best Mode(s) for Carrying Out the Invention

Referring to Figures 1 to 6 of the drawings, there is shown a pumping system 10
20 suitable for dewatering an underground mine.

The pumping system 10 comprises two pumps 11, 12 operable in timed sequence (as will be explained) in order to discharge contaminated water from

the underground mining site to ground surface 13 by way of a discharge pipeline 15. The contaminated water contains solids and so typically comprises a slurry. Accordingly, the contaminated water will hereafter be referred to as a slurry.

Each pump 11, 12 comprise a rigid outer casing 17 which is of cylindrical construction and which defines an interior space 19. Each casing 17 has a longitudinal axis inclined to the horizontal such that one end thereof is elevated in relation to the other. A first end plate 21 is mounted on the upper end of the casing 17 and a second end plate 22 is mounted on the lower end thereof.

A flexible tube structure 23 is accommodated in the interior space 19 within the outer casing 17 and is supported in a longitudinally taut condition. The flexible tube structure 23 comprises a length of "lay-flat" hose which is flexible yet substantially inelastic. The hose is substantially inelastic in the sense it does not have a memory tending to cause it to return to a particular state after being deflected therefrom.

The interior of the tube structure 23 defines a pumping chamber 25. Because of its flexible nature, the tube structure 23 is movable between laterally collapsed and expanded conditions for varying the volume of the pumping chamber 25. With this arrangement, the pumping chamber 25 can perform intake and exhaust strokes.

In the laterally collapsed condition, the tube structure 23 is relaxed and essentially collapsed upon itself, apart from the ends thereof which are supported in a manner to be explained later. In the laterally expanded condition, the tube structure 23 is inflated and stresses develop in the tube wall. This results in some longitudinal contraction or shortening of the tube structure, as will be described in more detail later.

One end of the tube structure 23 is supported on the lower end plate 22. Specifically, the lower end plate 22 incorporates an opening which defines a port 27 through which slurry undergoing pumping can enter and leave the pumping chamber 25 defined within the tube structure 23. The end plate 22 incorporates

a sleeve section 29 onto which the end of the tube structure 23 is sealingly engaged.

The other end of the tube structure 23 is attached to a movable support 31. The movable support 31 comprises a rigid end fitting 33 incorporating a side wall section 35 and an end wall section 37. The end of the tube structure 23 is sealingly fitted onto the side wall section 35. The end fitting 33 is supported on a guide rod 39 which extends through an opening 41 in the upper end plate 21. The guide rod 39 is sealingly and slidingly supported in the end plate 21. The outer end section of the guide rod 39 is fitted with a collar 43, with a compression spring 45 acting between the collar 43 and the outer face of the end plate 21. With this arrangement, the compression spring 45 urges the guide rod 39 outwardly and thus the end fitting 31 is urged towards the end wall plate 21. This arrangement movably supports the upper end of the tube structure 23 and accommodates longitudinal extension and contraction of the tube structure as will be explained later. Additionally, it assists in maintaining the tube structure 23 in the longitudinally taut condition.

The region of the interior space 19 surrounding the tube structure 23 within each pump 11, 12 defines an actuating chamber 47 for receiving an actuating fluid.

The pumping system 10 further includes a delivery means 49 for delivering slurry to be pumped to the pumping chambers in timed sequence as will be explained. The delivery means 49 communicates with a slurry reservoir, and includes a priming pump and a delivery line 50 which extends from the priming pump and which branches into two delivery branch lines 51, 52 with branch line 51 being associated with pump 11 and branch line 52 being associated with pump 52. Specifically, each delivery branch line 51, 52 communicates with a respective flow line 53 communicating with the pumping chamber 25 of the respective pump via port 27. Each flow line 53 incorporates a nozzle portion 55 adjacent the port 27, the purpose of which is to increase the velocity of slurry discharging from the pump chamber 25. An inlet check valve 57 in each branch line 51, 52 controls the flow direction of slurry along the branch line.

Each flow line 53 also communicates with the discharge pipeline 15 by way of a respective discharge branch line 61, 62. Each discharge branch line 61, 62 includes an outlet check valve 63 for controlling the flow direction of discharging slurry along the branch line.

- 5 A supply means 70 is provided for supplying actuating fluid to the actuating chambers 47 in timed sequence.

In this embodiment, the actuating fluid is hydraulic oil and the supply means 70 comprises a hydraulic circuit 71 communicating with the actuating chamber of each pump 11, 12. The hydraulic circuit 71 includes a reservoir 73 for hydraulic
10 oil and a hydraulic pump 75 for delivery of hydraulic oil under pressure to the actuating chambers 47. The hydraulic circuit 71 incorporates two branch lines 77, 79, with branch line 77 being associated with pump 11 and branch line 79 being associated with pump 12.

- 15 The actuating chamber 47 of each pump 11, 12 communicates with its respective branch line 77, 79 by way of transfer line 80 connected between the respective branch line and a port 83 which is formed in the outer casing 17 and which opens onto the actuating chamber 45.

- Each branch line 77, 79 incorporates an inlet control valve 81 on the upstream side of the respective transfer line 80 and an outlet control valve 82 on the
20 downstream side of the transfer line 80. The valves 81, 82 are adapted to operate in timed sequence under the control of a control system (not shown). Typically, the valves 81, 82 are solenoid valves operable in response to electrical signals from the control system.

- While operation the valves 81, 82 is controlled in timed sequence by the control
25 system, it should be noted that valves 57, 63 associated with slurry intake into, and discharge from, the pumping chambers 25 are simply check valves which respond to fluid pressures.

As alluded to above, a charge of slurry is expelled from each pumping chamber 25 under the influence of a charge of hydraulic oil entering the surrounding actuating chamber 47. the charge of hydraulic oil is spent at the completion of the discharge stroke. The spent charge of hydraulic oil is subsequently expelled
5 from the actuating chamber by inflation of the tube structure 23 during the next intake stroke of the pumping chamber 25. This sequence is of course controlled by timed actuation of the control valves 81, 82. Specifically, a discharge stroke for each pump 11, 12 is performed when the respective inlet valve 81 is open and the respective outlet valve 82 is closed. Similarly, an intake stroke is
10 performed when the respective outlet valve 82 is open and the respective inlet valve 81 closed, the outlet valve 82 needing to be open to allow expulsion of actuating fluid to provide inflation space for the tube structure 23 upon intake of slurry.

Operation of the pumping system 10 according to the first embodiment will now
15 be described.

At the commencement of a pumping operation using the pumping system 10, it is necessary to prime both pumps 11, 12 so that the pumping chamber 25 of each pump is fully loaded with slurry. The control system is then operated to delivery hydraulic oil to the actuating chamber 47 of pump 11. As the hydraulic oil fills the
20 actuating chamber 47 of pump 11, it causes the tube structure 23 exposed to the actuating fluid to progressively collapse. The progressive collapse of the tube structure 23 commences adjacent the upper end thereof and progresses uniformly downwardly towards the lower end thereof, expelling slurry contained therein through the port 27, along the discharge branch line 61 to pipeline 15.
25 The progressive collapse of the tube structure 23 from the closed upper end thereof towards the lower end thereof occurs because of a pressure differential between the upper and lower ends of the tube structure. The pressure differential is created because of the height difference between the upper and lower ends of the tube structure 23. The collapse is also assisted by the
30 difference in specific gravity of the hydraulic oil which constitutes the actuating fluid and water which is the primary constituent of the slurry.

At the completion of the discharge stroke of the pump 11, pump 12 is operated so as to commence its discharge stroke. During the discharge stroke of pump 12, pump 11 is caused to undergo an intake stroke, with slurry being delivered to the pumping chamber 25 thereof by way of the delivery means 49. The cycle
5 then repeats so that slurry is continuously pumped to the discharge pipeline 15 by the two pumps 11, 12 operating in timed sequence, with one pump performing an intake stroke while the other pump performs a discharge stroke and vice versa.

In order for there to be a substantially continuous delivery of pumped slurry to the
10 discharge pipeline 15, it is necessary for the duration of each intake stroke to be less than the duration of each discharge stroke. This provides time for the operation of the various control valves in the change-over-sequence from one pump to the other. During the change-over-sequence, there is a short interval during which both pumps are performing a discharge stroke thereby ensuring the
15 continuous flow in the discharge pipeline 15.

At the commencement of each pump stroke, the actuating chamber 47 of the respective pump is pressurised to the same pressure as the actuating chamber of the other pump (which is nearing the end of its discharge stroke). If the actuating chamber of the pump about to commence its discharge stroke is not so
20 pressurised prior to commencement of its discharge stroke, there will be a pressure loss which would disrupt continuous delivery to the discharge pipeline 15 so creating the potential for hydraulic hammer in the pipeline. A severe increase in energy consumption by the pump system would also occur because of consequent deceleration/acceleration of the output flow along the discharge
25 pipeline 15.

During operation of the pumping system 10, it is most important to ensure that each pumping chamber 25 is fully filled with slurry prior to commencement of its pumping stroke. Furthermore, it is most important that the pump stroke commence at the appropriate time in the cycle of operation of the pumping
30 system. Without these requirements being satisfied, the tube structure 23 could.

ultimately be damaged by ongoing application of pressure through the actuating fluid after the slurry charge within the respective pumping chamber 25 has fully discharged. This could, for example, lead to the tube structure 23 being forced through the port 27.

- 5 There are various ways in which operation of the pumping system can be monitored to ensure that each pumping chamber 25 is filling correctly prior to commencement of a discharge stroke. One way would involve monitoring the pressure differential existing between the actuating chamber 47 and the pumping chamber 25. By way of explanation, when slurry is entering one of the pumping
10 chambers 25 through the respective port 27, actuating fluid is being discharged from the actuating chamber. In other words, the outlet control valve 82 in the hydraulic circuit associated with that particular actuating chamber 47 is open to allow the expulsion of the actuating fluid. As there is minimal back pressure in the actuating chamber 47 (because the outlet valve 82 is open), the slurry can
15 inflate the tube structure 23 as the actuating fluid is expelled. When the tube structure 23 is fully loaded, the delivery means 49 continues to apply pressure to the tube structure, with the pressure being absorbed by the tensile properties of the tube structure. The internal pressure within the tube structure 23 causes the tube structure to become tight and so assume its maximum possible inflated
20 condition. With the outlet valve 82 from the actuating chamber 47 still open at this stage, there will be no pressure exerted on the actuating fluid remaining in the actuating chamber 47 (as the tube structure 23 can expand no further). Consequently, there is a pressure differential which can be detected and thereby used to provide an indication that the pumping chamber 25 is fully loaded.
- 25 Another detection system may utilise the shortening effect of each tube structure 23 when it moves from a relaxed condition to a fully loaded condition. The shortening effect can be seen with reference to Figures 3 to 6 of the drawings. Figures 5 and 6 illustrate the closed end section of the tube structure 23 when it is in a relaxed state. As can be seen with reference to Figures 3 and 4, when the
30 tube structure 23 is fully loaded, the radial expansion of the tube structure leads to longitudinal contraction, with the result that there is an overall shortening of the

tube structure. The shortening of the tube structure 23 is accommodated by the movable support 31. The extent of the shortening can be measured, for example with reference to movement with the guide rod 39. This can then be used to provide a signal indicating that the pumping chamber is fully loaded.

- 5 In the first embodiment shown in Figures 1 to 6, the closed end of each tube structure 23 is achieved by a closure 90 of generally circular configuration.

- In the second embodiment shown in Figures 7 to 11, the closed end of each tube structure 23 is achieved by a closure 92 which is oblong. The shortening affect of the tube structure is magnified by the oblong shaped closed end 92 as shown
10 in Figures 7 to 11 as compared to the circular closed end 90 of the first embodiment. The flatter oblong end 92 when compared to the circular end 90 causes an increase in the deformation of the tube structure 23 and hence an increase in the shortening effect. This increase in shortening effect can be used to improve the sensitivity of the control system detection device for the fully
15 loaded condition.

It should, however, be understood that the end of the tubular structure 23 can be closed in any appropriate way.

- The inclination of the pumps 11, 12 is so selected that if settlement of solid particles within the slurry were to occur while the slurry is within the pumping
20 chamber 25, the settled particles accumulate at the lower end of the pumping chamber adjacent the port 27. The settled particles are then collected and discharged by the outgoing slurry charge during the next discharge stroke as a result of the higher velocity flow which exists at the outlet.

- In the first embodiment, the actuating fluid comprised hydraulic oil and the supply
25 means 70 incorporated a hydraulic circuit. Other arrangements are, of course, possible. In the embodiment shown in Figure 12, the actuating fluid is water and the supply means 70 comprises a water reservoir 91 disposed at an elevated location which in this embodiment is at ground level. The elevated location of the reservoir 91 provides a supply of clean water at an appropriate pressure head for

use as the actuating fluid. Spent water discharging from the actuating chambers is at a lower pressure and can be reticulated throughout the underground mine site for any purpose where clean water might be required.

From the foregoing, it is evident that the present invention provides a simple yet
5 highly effective pumping system which can pump fluids at high pressure in a uniform flow regime. The pump system 10 can operate at relatively slow pumping cycles in comparison to prior art devices and so valve systems used in the pump system are operating under less arduous conditions. By way of example, each pump 11, 12 within the pump system 10 can operate at a rate of
10 about 2 cycles per minute which is significantly lower than the usual rate of 60 to 80 cycles per minute for conventional piston pumps and diaphragm pumps used in mining environments.

It should be appreciated that the scope of the invention is not limited to the scope of the embodiment described. In this regard, it should be understood that a
15 pumping system according to the invention may have applications in various areas where fluid pumping is required and need not be limited to dewatering of underground mines.

Further, it should be understood that while the pump system 10 according to the embodiment utilises two pumps 11, 12 operating in timed sequence, there may
20 be applications where only one pump is required (where intermittent discharge flow is acceptable), or alternatively there may be applications where it is possible to use a series of more than two pumps operating in sequence.

Improvements and modifications may be incorporated without departing from the scope of the invention.

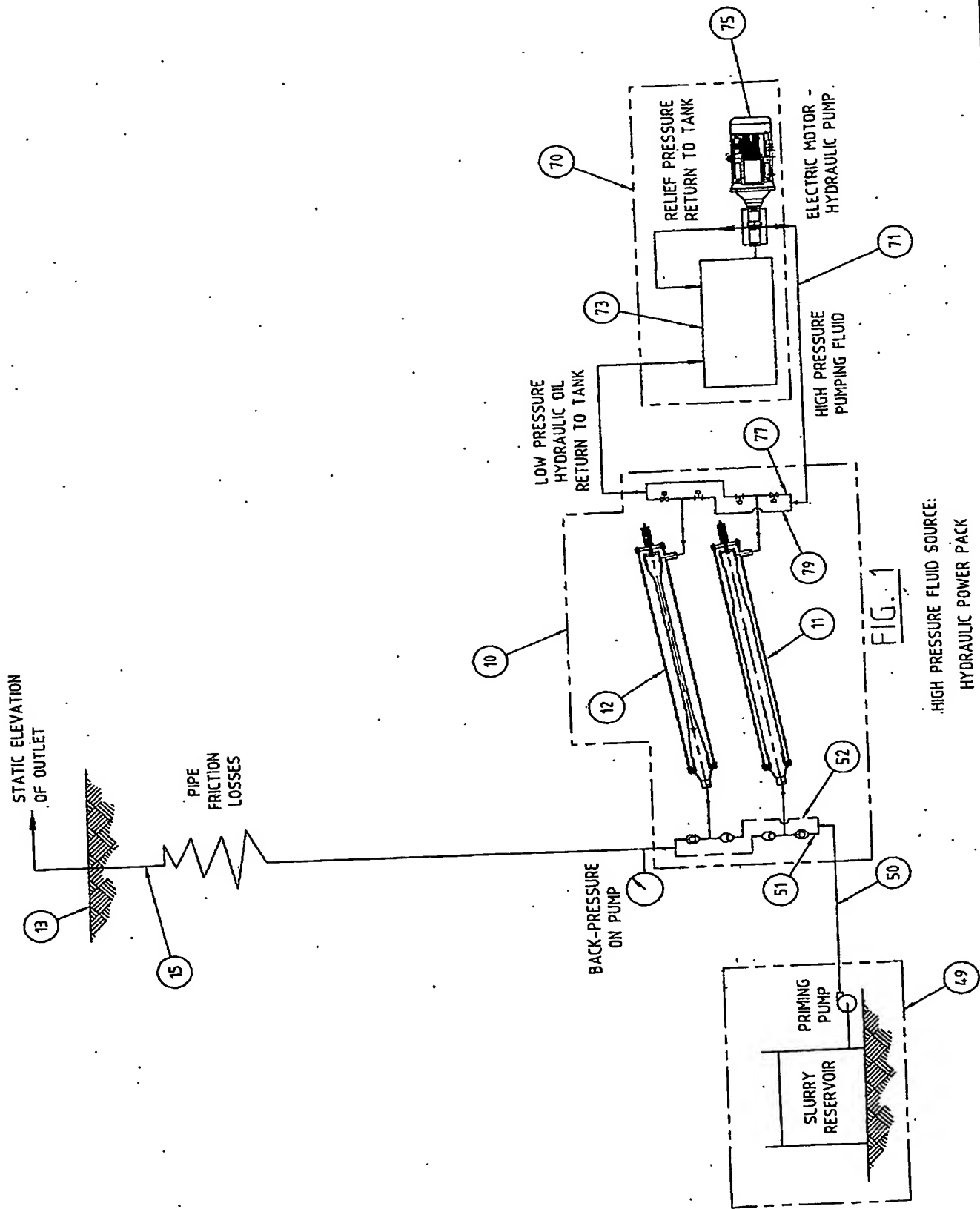
Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

5

Dated this twenty-ninth day of July 2002.

Combined Resource Engineering Pty Ltd
Applicant

Wray & Associates
Perth, Western Australia
Patent Attorneys for the Applicant(s)



HIGH PRESSURE FLUID SOURCE:
HYDRAULIC POWER PACK

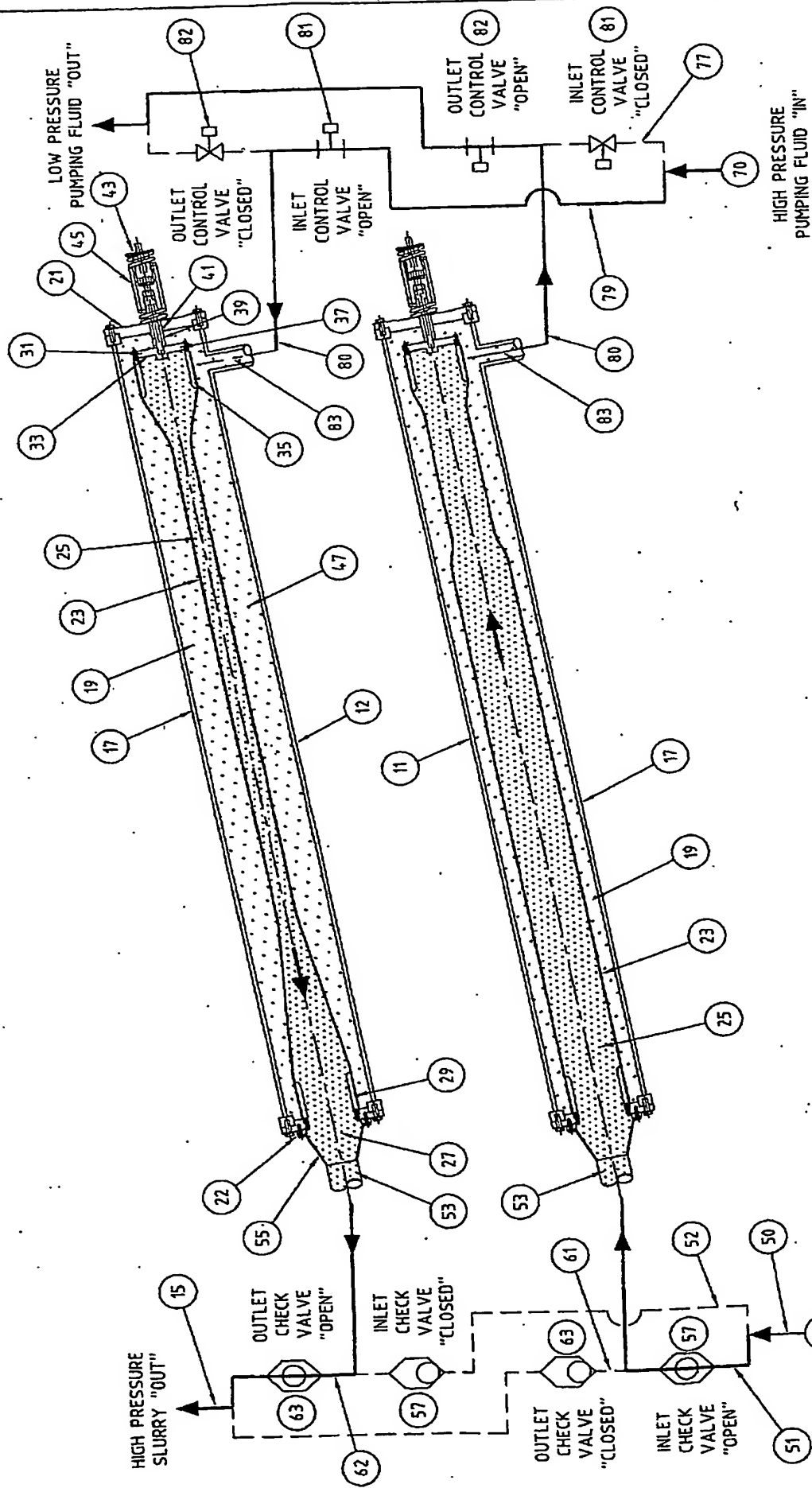
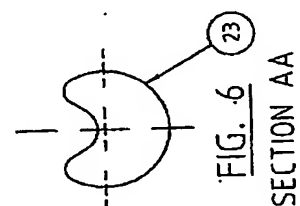
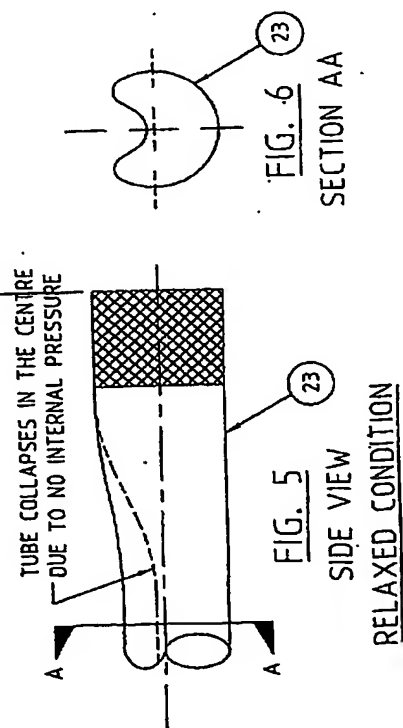
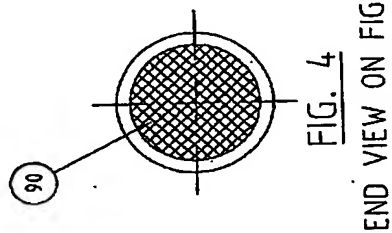
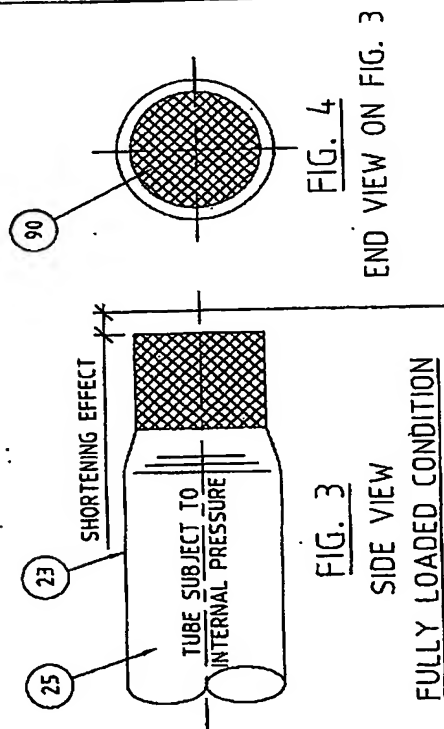


FIG. 2
 SCHEMATIC SHOWS:
 PUMP 11 DURING INTAKE STROKE
 PUMP 12 DURING DISCHARGE STROKE



CIRCULAR END CLOSURE

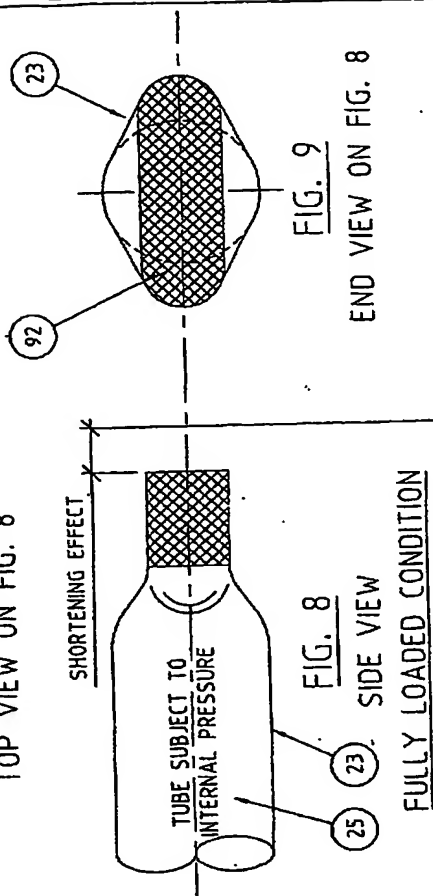
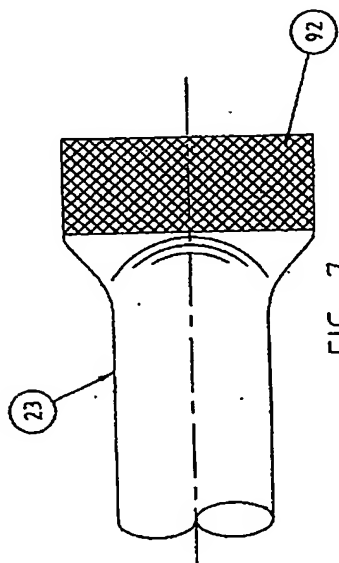


FIG. 9

END VIEW ON FIG. 8

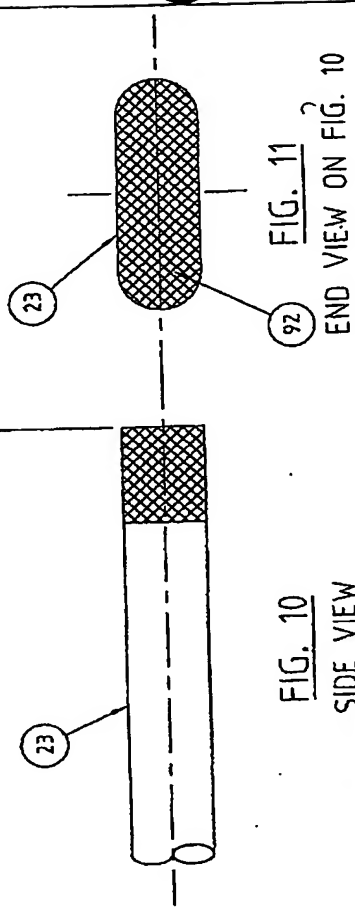


FIG. 11

END VIEW ON FIG. 10

OBLONG END CLOSURE

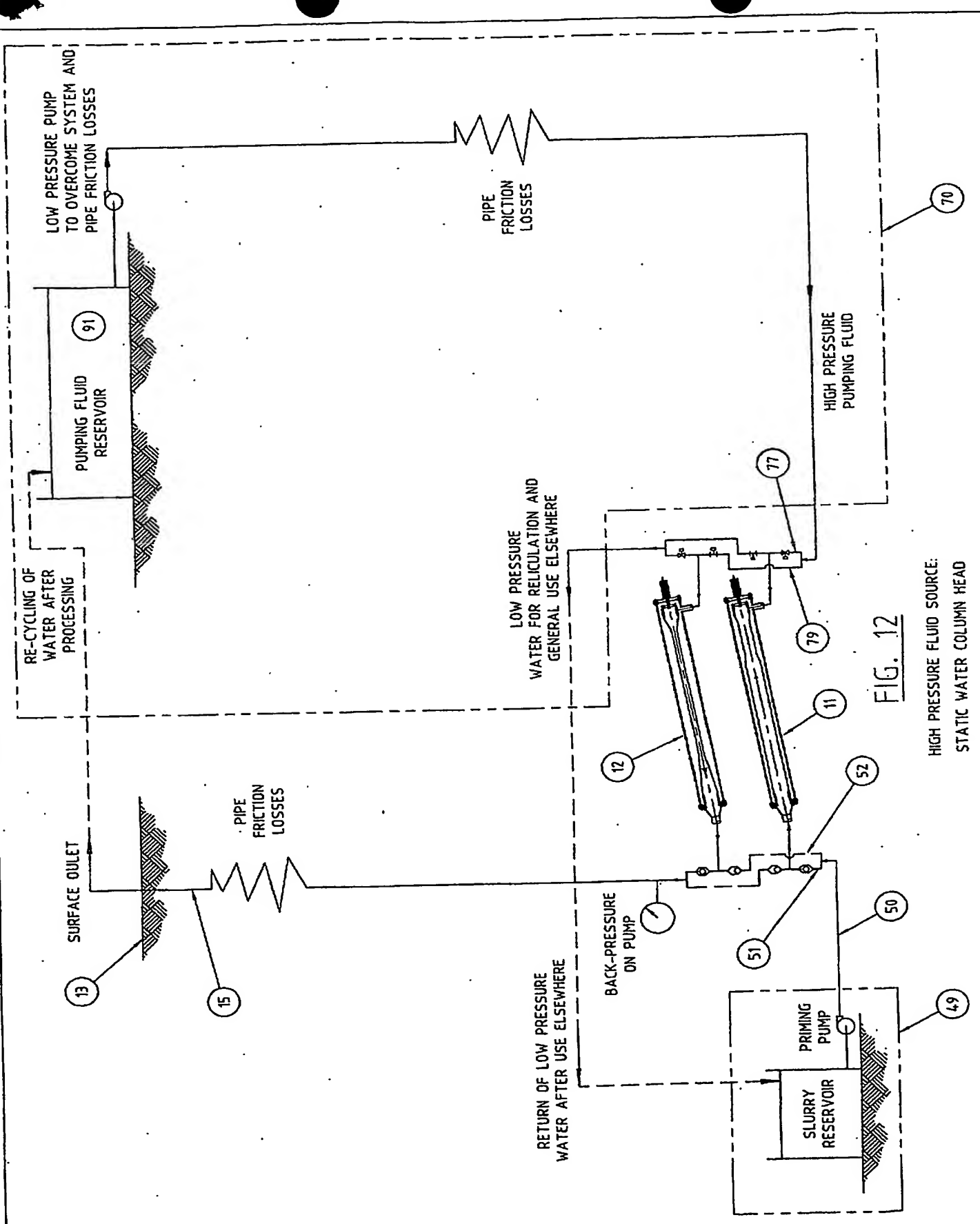


FIG. 12

HIGH PRESSURE FLUID SOURCE:
STATIC WATER COLUMN HEAD

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